



# THE TENNESSEE SOLAR VALUE CHAIN

A WORKFORCE DEVELOPMENT NEEDS ASSESSMENT

PART OF THE TENNESSEE STATE ENERGY  
PROGRAM ARRA FUNDING

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THE UNIVERSITY of  
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## ABOUT THE TENNESSEE SOLAR INSTITUTE

The Tennessee Solar Institute is a Center of Excellence at the University of Tennessee (UT) and Oak Ridge National Laboratory (ORNL). It brings together scientists, engineers, and other technical experts with industry leaders and policymakers to bring about transformative changes in the field of solar-generated energy production; facilitate the deployment of solar energy in real-world applications; and promote economic development in Tennessee.

The mission of the Tennessee Solar Institute is to advance understanding of solar innovation and to inspire new ideas that speed the deployment and implementation of solar-based technology.

The Tennessee Solar Institute was launched in 2010 as part of the State of Tennessee's Volunteer State Solar Initiative (VSSI). VSSI is a comprehensive solar energy and economic development program that focuses on job creation, education, renewable power production, and technology commercialization efforts to reduce the cost and increase the efficiency of solar energy. VSSI is part of the state's strategic efforts to grow Tennessee's industrial base and further Tennessee as a leader in the \$240 billion global clean energy sector.

The Tennessee Solar Institute has awarded \$23.5 million of solar innovation and installation grants that have leveraged more than \$40.3 million in private investments, with a total cumulative benefit to the state's economy in excess of \$63.8 million.

TSI, along with the UT's Center for Industrial Services (CIS) and ORNL, is well-positioned to assist industry with technology development and assess industry and workforce needs for an emerging clean energy economy.



**TSI HAS LEVERAGED \$40.3 MILLION IN PRIVATE INVESTMENTS WITH A TOTAL CUMULATIVE BENEFIT TO THE STATE'S ECONOMY IN EXCESS OF \$63.8 MILLION.**

## FOREWORD

One of the bright spots in Tennessee's and the country's economy continues to be clean energy. The American solar industry grew by 69 percent in the past year, making it one of the fastest growing sectors in the U.S. economy. The state of Tennessee is no exception. It too has experienced rapid growth in the solar industry.

Tennessee is well positioned to benefit from the ongoing solar boom. With companies old and new investing and innovating, the solar sector offers a chance to put some of our 297,000 unemployed citizens back to work, while growing our state's economy.

But if Tennessee does not capitalize on its advantages, the state's economy risks losing these jobs and business opportunities to neighboring states, which are also growing their solar sectors.

That's where the Tennessee Solar Institute comes in. Our job is to provide the kind of workforce development and technical assistance that will allow businesses in Tennessee's solar value chain to compete and thrive.

This report is the first statewide attempt to capture a high-level view of the solar sector in Tennessee. It includes a status report on the solar workforce and it looks at the challenges facing this burgeoning industry. Simply put, the goal of this needs assessment is to answer the following questions:

- *What businesses are in the solar value chain in Tennessee?*
- *What do they need?*

By understanding the needs of the state's solar value chain and assessing the most strategic options to support it, Tennessee can gain a competitive edge and emerge as a national and international leader in the global clean energy market.

— **John Sanseverino**  
Tennessee Solar Institute

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## EXECUTIVE SUMMARY

This report represents the first comprehensive look at the solar industry in Tennessee. It details the size and shape of Tennessee's solar value chain (TNSVC) and assesses the sector's workforce development needs.

Prepared by the Tennessee Solar Institute following extensive research, it paints a portrait of the state's solar employers and workforce, and describes the challenges facing this young and growing industry.

In the course of preparing this comprehensive needs assessment, clear themes have emerged. Among them:

- The solar industry is growing rapidly, despite tough economic times. This is true in Tennessee, across the nation, and around the world.
- A growing solar industry represents a genuine economic development opportunity for Tennessee.
- Feedback from businesses in the solar value chain points to specific needs that must be met if the state's solar sector is to keep growing and reach its full potential. These needs include specialized training, operational guidance, and workforce development.
- Tennessee can either capitalize on its many advantages and help its solar sector continue to grow and thrive, or risk conceding solar sector leadership—and the jobs that go with it—to neighboring states.

## BACKGROUND

Since 2003, the state of Tennessee has made coordinated investments in advanced energy production and energy efficiency technologies. The goals: to establish Tennessee as a leader in clean energy technology, and to capture a share of this global \$240-billion-dollar industry.

These investments have leveraged existing resources and federal programs, spurring solar sector growth, and helping put Tennesseans back to work.

Other studies back up these findings. For example:

Middle Tennessee State University's "Green Jobs Report" found that clean energy jobs are the fastest growing sector in Tennessee. The solar sector employed more than 6,400 state residents in 2010.<sup>1</sup>

The Brookings Institute (July 2011) counts 76,031 clean energy jobs in Tennessee.<sup>2</sup> Nationwide from 2003 to 2010, the clean economy grew by 8.3%—almost double what the overall economy grew during those years.

1 Murat Arik and David A. Penn. Green Jobs in Tennessee: Economic Impact of Selected Green Investments. Middle Tennessee State University. 2011.

2 Mark Muro, Jonathan Rothwell, and Devashree Saha. Sizing the Clean Economy. A National and Regional Green Jobs Assessment. The Brookings Institute. Metropolitan Policy Program. July 2011.

A report by Pew Charitable Trusts (June 2009) highlighted Tennessee as one of three states in the country – along with Colorado and Oregon – with a large and fast-growing clean-energy sector as part of the state economy.

## OBJECTIVES

The objectives of this solar industry workforce development needs assessment are to:

- identify all companies in Tennessee's solar value chain,
- determine the health and needs of these companies,
- identify workforce development needs, and
- determine the challenges the industry faces to grow in Tennessee.

This information was gathered through the use of both online questionnaires and site visits.

## THE SIZE AND SHAPE OF TENNESSEE'S SOLAR VALUE CHAIN

The study found that the Tennessee solar value chain (TNSVC) comprises 236 for-profit and non-profit entities, ranging from large solar-related industries with established roots in the state to companies recently recruited to Tennessee to small entrepreneurial firms.

The details:

- In 2008, Tennessee had less than 1.3 kW installed solar PV capacity, enough to power 20% of one average home. By the end of 2011, solar capacity grew to approximately 17 MW, enough to power over 1,300 average homes. Tennessee now ranks 22nd nationwide in installed solar PV.
- Over 6,400 Tennessee jobs are in solar and solar-related industries, including solar photovoltaic installers, team assemblers, electricians and energy auditors, according to MTSU's "Green Jobs Report" (2011).<sup>3</sup>
- Tennessee's solar sector is young and rapidly growing. There were 33 new entrants in the solar value chain since 2008—15 of those in 2010 alone.
- The average age of companies responding to the survey is 24.7 years, while the average number of years doing business in the solar market is only 2.9 years. This shows that, in addition to new start-ups, well-established companies are diversifying into solar markets.
- The 236 organizations in Tennessee's solar value chain include 174 for-profit and 62 non-profit entities.
- Of the firms in Tennessee's solar value chain firms, 58% are small businesses with 25 employees or less.

<sup>3</sup> Murat Arik and David A. Penn. Green Jobs in Tennessee: Economic Impact of Selected Green Investments. Middle Tennessee State University. 2011.

- Tennessee's solar value chain spans research & development (with 18 firms/ organizations in this sector), materials & manufacturing (22), distribution (24), installation (87), service (52), education (20), and other (13).
- Installation (50%), service organizations (21%), and manufacturing/ materials (13%) accounted for approximately 84% of the for-profit firms.
- Educational (20), R&D (14), service (15), and other solar organizations (13) accounted for the non-profit organizations identified as part of the solar value chain.
- Eighteen entrepreneurs in Tennessee's solar value chain took steps to protect their intellectual property.

## WHAT DOES TENNESSEE'S SOLAR SECTOR NEED TO KEEP GROWING?

Surveys and site visits focused on identifying obstacles and challenges that may keep Tennessee's solar value chain from continuing to grow, and on identifying actions that may help them continue to thrive.

All of the firms surveyed reported strong demand for their goods and services. This was especially true for solar manufacturing companies: Since the beginning of 2010, the price of solar panels has dropped by 30 percent<sup>4</sup>, and costs continue to fall, making solar more affordable.

4 Solar Energy Industries Association, Facts on America's Solar Industry. November 3, 2011.

[http://www.seia.org/cs/about\\_solar\\_energy](http://www.seia.org/cs/about_solar_energy)

Firms reported the following needs:

- **Workforce Development:** The need for workforce education and training is constant. New skilled workers are required for expansion, electrical and building codes and permitting standards are continuously evolving, and technology is changing rapidly.
- **General Business Operations:** Younger firms, especially, say they need help in the following areas:
  - Learning how to increase productivity
  - Understanding and complying with occupational health and safety rules
  - Incorporating quality management into business operations training
  - Strategic business planning
  - Managing risk within their supply chains
- **Manufacturers' training needs:** The solar manufacturing sub sector includes mature solar businesses, new solar start-ups, and existing manufacturing companies seeking to expand into the solar market. The types of needs expressed by these manufacturing firms are aimed at improving their operations and competitiveness in a global market. On-site assessments identified a range of needs aimed at establishing and/or improving manufacturing operations. These include:
  - Lean implementation training
  - Quality management training
  - Manufacturing process and equipment training

- Equipment maintenance training
- Visual performance tracking training
- Problem solving training
- Safety training
- Supplier development training
- Inventory management training
- Project management training
- Supervisory and leadership skills training

Execution of the Jobs4Tn Plan, designed to assist existing businesses in expansion and competitiveness, would further strengthen the solar manufacturing sector. Additionally, **TN-SCORE** will be a valuable asset to the solar manufacturing industry. TN-SCORE (Tennessee Solar Conversion and Storage using Outreach, Research and Education) provides a unique opportunity for collaboration between academe, government and the private sector to increase Tennessee's national and international competitiveness in the energy sector.

## CONCLUSION

Tennessee's solar energy industry has continued to grow, put people back to work and enable Tennessee's workforce with 21st century skills, even while much of the state's economy has struggled. By understanding the needs of the state's solar value chain and assessing the most strategic options to support it, Tennessee can gain a competitive edge and emerge as a national and international leader in the \$240 billion global clean energy market.

The solar energy industry represents a viable option to help put Tennesseans back to work while enabling our workforce with 21st century skills.

Despite rapid growth, Tennessee's solar sector faces challenges, including competition from other states and nations, and the constant need for investment. Helping companies with the training, assistance, and workforce development needs identified in this study would help them improve their operations and competitiveness, making them more profitable and more attractive to investors. Continuing efforts to cultivate Tennessee's solar value chain will help our state earn a growing slice of the emerging clean energy economy.

# INTRODUCTION

## UNDERSTANDING THE TENNESSEE SOLAR VALUE CHAIN

Early stages of this Workforce Development Needs Assessment focused on gaining a basic understanding of the solar value chain at both the national and local level. A review of relevant literature and available online data resulted in a variety of representations and valuations. But the result of this workforce development needs assessment show strong growth in Tennessee's solar industry.

The evolution of the solar industry in the Appalachian region, including parts of Tennessee, was dependent upon several interrelated constructs, including "...demand that is stimulated by government mandates, feed-in tariffs, tax incentives, rebates, price of conventional energy and carbon offsets. It also depends on supply that is influenced by production capacity, availability of raw materials, process innovation, rate of learning, and economies of scale." [Industry Structure and Company Strategies of Major Domestic and Foreign Wind and Solar Energy Manufacturers: Opportunities for Supply Chain Development in Appalachia (Susman and Glasmeier (2009))].

In 2009, installations of solar PV in the United States were "booming," and very high growth rates were expected in 2010 and 2011. In fact, installed capacity doubled nationwide in 2010 from 2009 with a reshuffling of states in the top ten (Tables 1 and 2). In 2010, Tennessee ranked 18th in installed capacity for the year (Table 1) and 22nd in cumulative capacity over the past 3 years (Table 2). [The U.S. Solar Market Trends (Sherwood 2011)].

Approximately 23.2 MW of new photovoltaic (PV) generation capacity has been installed in Tennessee since 2009, extending into 2012 (Table 3). Approximately 13.2 MW will be installed in 2011 alone. This was made possible through incentive programs such as the Tennessee Clean Energy Technology Program and the Tennessee Solar Institute's Solar Installation and Solar Innovation Grant Programs. In addition, the USDA Rural Energy for America Program and private investments are having a significant impact on solar PV installation in Tennessee. These incentive programs, combined with the 1603 Tax Grants and TVA's Generation Partners Program, have accelerated PV installation in Tennessee at a rapid pace. (For comparison, in 2008, there were only 1.3 kW of PV enrolled in TVA's Generation Partners Program.)

The goal for solar and other forms of clean energy is to become cost competitive without subsidies in 10-15 years, according to U.S. Secretary of Energy Steven Chu. Research and development is key because technological advances drive costs down, evidenced by solar panel's 30 percent drop in cost since the beginning of 2010. Earlier this year, the US Department of Energy (DOE) launched a program aiming to deliver grid-parity solar photovoltaics by 2020. Many compare this to President Kennedy's successful "moon-shot" initiative in the 1960's.

**TSI'S SOLAR INSTALLATION  
GRANTS HAVE LEVERAGED  
\$26.3 MILLION IN PRIVATE  
INVESTMENT.**

It is important to note the solar and clean energy industries do not compete on a level playing field with traditional sources of energy. Fossil fuels including oil, natural gas and coal received more than twice the level of subsidies that renewable energy sources got from the U.S. government in fiscal 2002 through 2008. Government spending and tax breaks amounted to \$72.5 billion for fossil fuels, compared to \$29 billion for renewable energy, from 2002-2008.<sup>5</sup>

<sup>5</sup> Estimating U.S. Government Subsidies to Energy  
Sources: 2002-2008. The Environmental Law Institute.  
September 2009. [http://www.elistore.org/reports\\_detail.asp?ID=11358](http://www.elistore.org/reports_detail.asp?ID=11358)

**TABLE 1. TOP TEN STATES RANKED BY GRID-CONNECTED PV CAPACITY INSTALLED IN 2010**

| 2010 RANK BY STATE | 2010<br>(MW <sub>DC</sub> ) | 2009<br>(MW <sub>DC</sub> ) | 2008<br>(MW <sub>DC</sub> ) | 2010<br>MARKET SHARE | 2009<br>RANK |
|--------------------|-----------------------------|-----------------------------|-----------------------------|----------------------|--------------|
| 1. California      | 252.0                       | 213.7                       | 197.6                       | 28%                  | 1            |
| 2. New Jersey      | 132.4                       | 57.3                        | 22.5                        | 15%                  | 2            |
| 3. Nevada          | 68.3                        | 2.5                         | 14.9                        | 8%                   | 15           |
| 3. Arizona         | 63.6                        | 21.1                        | 6.2                         | 7%                   | 5            |
| 3. Colorado        | 62.0                        | 23.4                        | 21.7                        | 7%                   | 4            |
| 3. Pennsylvania    | 46.5                        | 4.4                         | 3.0                         | 5%                   | 13           |
| 3. New Mexico      | 40.9                        | 1.4                         | 0.6                         | 5%                   | 19           |
| 3. Florida         | 34.8                        | 35.7                        | 0.9                         | 4%                   | 3            |
| 3. North Carolina  | 28.7                        | 6.6                         | 4.0                         | 3%                   | 10           |
| 10. Texas          | 25.9                        | 4.2                         | 1.2                         | 3%                   | 14           |
| 18. Tennessee      | 3.8                         | 0.5                         | <0.1                        | 0.4%                 | 24           |
| All Other States   | 134.5                       | 67.1                        | 272.6                       | 15%                  | -            |
| <b>Total</b>       | <b>889.5</b>                | <b>437.5</b>                | <b>311.1</b>                |                      | -            |

Source: IREC 2010 Updates and Trends

**TABLE 2. TOP TEN STATES RANKED BY GRID-CONNECTED PV CUMULATIVE INSTALLED CAPACITY THROUGH 2010**

| 2010 RANK BY STATE | 2010 (MW <sub>DC</sub> ) | MARKET SHARE |
|--------------------|--------------------------|--------------|
| 1. California      | 1,022                    | 48%          |
| 2. New Jersey      | 260                      | 12%          |
| 3. Colorado        | 121                      | 6%           |
| 4. Arizona         | 110                      | 5%           |
| 5. Nevada          | 105                      | 5%           |
| 6. Florida         | 73                       | 3%           |
| 7. New York        | 56                       | 3%           |
| 8. Pennsylvania    | 55                       | 2%           |
| 9. Hawaii          | 45                       | 2%           |
| 10. New Mexico     | 43                       | 2%           |
| 22. Tennessee      | 4.7                      | 0.2%         |
| All Other States   | 259                      | 12%          |
| <b>Total</b>       | <b>2,153</b>             | -            |

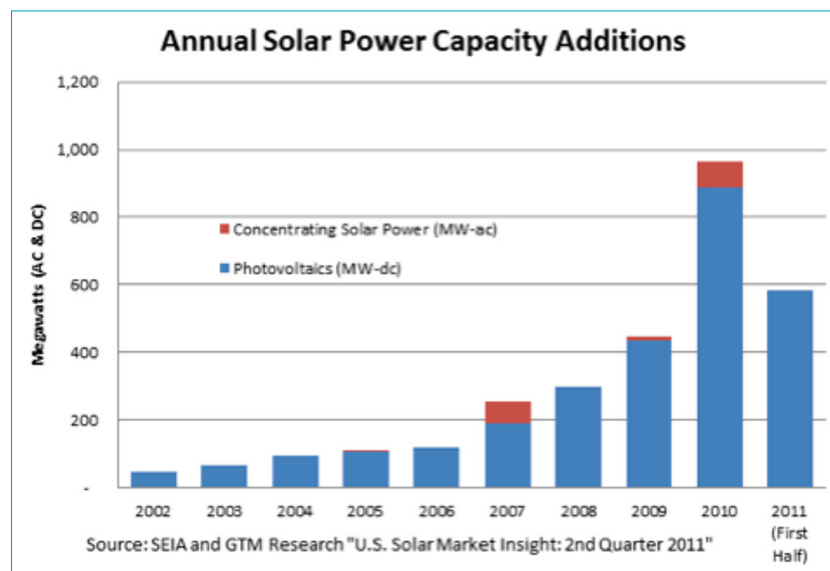
Source: U.S. Solar Market Trends 2010.

**SHARP SOLAR HAS NEARLY DOUBLED ITS EMPLOYMENT IN THE LAST FOUR YEARS AND CURRENTLY EMPLOYS 400 PEOPLE AT ITS MANUFACTURING PLANT IN MEMPHIS.**

These data focus on the installed PV capacity nationwide (Tables 1 and 2). Monitoring the increased PV installed is generally recognized as a barometer for the health of the solar manufacturing industry. The rapid rise of installed PV in Tennessee parallels the national trend (Figure 1).

As more solar is installed, the demand for manufactured components increases.

**FIGURE 1. GROWTH OF SOLAR PV INSTALLATIONS IN U.S.**



**SHOALS TECHNOLOGIES, A SOLAR ENERGY COMPONENT MANUFACTURER AND EXPORTER BASED IN PORTLAND, IS EXPECTED TO OPEN AN ADDITIONAL 75,000-SQUARE-FOOT, \$10.5 MILLION MANUFACTURING PLANT IN FEBRUARY, ADDING 300 TO 400 NEW JOBS OVER THE NEXT FOUR YEARS**

**[SOURCE]**

**TABLE 3. SOLAR PV CUMULATIVE INSTALLATION IN TENNESSEE (2009-2011)**

| PROJECT/RESPONSIBLE PROGRAM               | 2010 (MW <sub>DC</sub> ) |
|---|--------------------------|
| Tennessee Clean Energy Technology Program | 1.7                      |
| Tennessee Solar Institute                 | 6.7*                     |
| West Tennessee Solar Farm                 | 5.2                      |
| USDA Rural Energy for America Program     | 1.3                      |
| Private installations and solar farms     | 8.6                      |
| <b>Total</b>                              | <b>23.2+</b>             |

\*This is the approximate sum of the capacity installed under the Solar Installation Grant Program and the Solar Innovation Grant Program.

+The USDA REAP program co-funded 20 TSI projects. The total reflects the REAP contribution of non-TSI funded projects.

SOLAR WORKFORCE

One revelation resulting from the literature review and contact with solar industry and Department of Labor personnel was that, with the exception of Solar Photovoltaic (PV) Installers (Figure 2), there are no official U.S. Bureau of Labor Statistics (BLS) classifications dedicated to solar jobs. Thus, solar PV job tracking by standard labor data is challenging. Since BLS does not track employment data for the solar power industry, the most authoritative data on solar jobs from a national perspective appears to be data provided by the National Solar Job Census report.

WACKER CHEMIE AG IS BUILDING A \$1.45 BILLION POLYCRYSTALLINE SILICON FACILITY NEAR CLEVELAND, AND IS EXPECTED TO EMPLOY 650 WORKERS [SOURCE]

FIGURE 2. BUREAU OF LABOR STATISTICS STANDARD OCCUPATIONAL CLASSIFICATION (SOC) MARCH 11, 2010.

47-2231 SOLAR PHOTOVOLTAIC INSTALLERS

Assemble, install, or maintain solar photovoltaic (PV) systems on roofs or other structures in compliance with site assessment and schematics. May include measuring, cutting, assembling, and bolting structural framing and solar modules. May perform minor electrical work such as current checks. Excludes solar thermal installers who are included in "Plumbers, Pipefitters, and Steamfitters (47-2152). Excludes solar PV electricians who are included in "Electricians" (47-2111). [http://www.bls.gov/soc/2010/soc472231.htm]

The Tennessee Green Jobs Report (2011)<sup>6</sup> provides results of a green jobs survey identifying the numbers of people working in Tennessee’s green economy in 2010. Solar-related jobs were captured only as part of the renewable energy section of this report. Only Solar PV Installers were explicitly tracked by Standard Occupational Classification (SOC). Other solar-related jobs (e.g., electricians, engineers, manufacturing workers, contractors, and construction) are embedded in the data for SOC job classifications under “Renewables,” and so are not explicitly quantified in this report. Table 4 reflects data from the Green Jobs study. The data for Team Assemblers, Electricians, and Energy Auditors are presented to illustrate projected growth rates in job sectors that include solar employees.

6 Tennessee Department of Labor & Workforce Development, Employment Security Division, Labor Market Information Section

TABLE 4. ACTUAL (AND SOLAR RELATED) PROJECTED JOB GROWTH RATES IN TENNESSEE

| SOC    | OCCUPATION TITLE              | CURRENT # OF GREEN JOBS | ESTIMATED # OF NEW GREEN JOBS | PROJECTED GROWTH RATE % |
|--------|-------------------------------|-------------------------|-------------------------------|-------------------------|
| 472231 | Solar Photovoltaic Installers | 62                      | 75                            | 120.5                   |
| 512092 | Team Assemblers               | 4126                    | 167                           | 4                       |
| 472111 | Electricians                  | 1979                    | 201                           | 18.6                    |
| 131199 | Energy Auditors               | 244                     | 11                            | 4.7                     |

Source: 2010 Green Jobs Report, Tennessee Department of Labor and Workforce Development



The National Solar Jobs Census<sup>7</sup> is promoted as the first attempt to quantify the current employment and projected growth of the United States solar industry. It is based on a statistical sampling of solar firms throughout the nation, plus state-level data. The report provides a national perspective of the top solar job markets in the nation. As of August 2011, there are an estimated 100,237 solar related jobs in the nation ([www.thesolarfoundation.org](http://www.thesolarfoundation.org)). Plans for an updated census in 2012 are underway. Some important conclusions from the National Solar Jobs Census are provided in Table 5 below.

7 National Solar Jobs Census (2011),  
The Solar Foundation. October 2011.  
[http://thesolarfoundation.org/research/  
national-solar-jobs-census-2011](http://thesolarfoundation.org/research/national-solar-jobs-census-2011)

**TABLE 5. OBSERVATIONS OF THE 2011 NATIONAL SOLAR JOBS CENSUS**

| <b>AS OF AUGUST 2011:</b>  |
|--|
| There are 100,237 solar workers in the United States, up from 93,000 last year. This represents an overall growth rate of 6.8% over the past year, nearly 10 times higher than the national average employment growth rate of 0.7% |
| Solar job growth over the next 12 months is anticipated to be almost 24%, representing approximately 24,000 additional new jobs. Nearly half of all solar firms expect to add solar employees over the next 12 months.             |
| Employers from all of the studied solar sub sectors expect significant employment growth over the next 12 months.  |
| Nearly half of the installation firms expect to be hiring in the next year, and these firms expect to add 13,068 jobs over the next year. This represents a 25% growth rate.   |
| Almost 44% of manufacturing firms expect to add jobs over the next year, with 3,473 jobs expected to be created during that time. This represents a 14% growth rate.   |
| More than 45% of sales and distribution firms expect to add jobs over the next year, creating 6,188 jobs. This represents a 35% growth rate.   |
| A quarter of utility respondents surveyed in 2010 were expecting to hire additional renewable energy workers through 2012, with employment growth projections ranging from 10 to 19 percent.                                       |

Source: [2011 National Solar Jobs Census](#), [The Solar Foundation \(October 2011\)](#)

Workforce development training and education related to solar energy – and to renewables in general – are taking place all across the state. The Tennessee Board of Regents (TBR) system (universities, community colleges, and technology centers), as well as the University of Tennessee, are offering credit and/or non-credit courses in solar-related technologies, as well as other green energy courses and training.

With the above observations in mind, the focus of this Tennessee solar value chain (TNSVC) assessment is defining the firms that are in, or want to be in, the solar value chain; identifying the sectors of the value chain in which these firms participate; and exploring the needs of these firms in terms of establishing, developing, and maintaining a viable workforce and business operation in the solar industry.

**HEMLOCK SEMICONDUCTOR IS BUILDING A \$1.2 BILLION POLYSILICON PLANT IN CLARKSVILLE, WITH PLANS FOR EXPANSION. CONSTRUCTION HIRES REACHED OVER 2,000 IN 2011 AND THE HIRING OF MORE THAN 500 FULL-TIME EMPLOYEES IS UNDERWAY.**

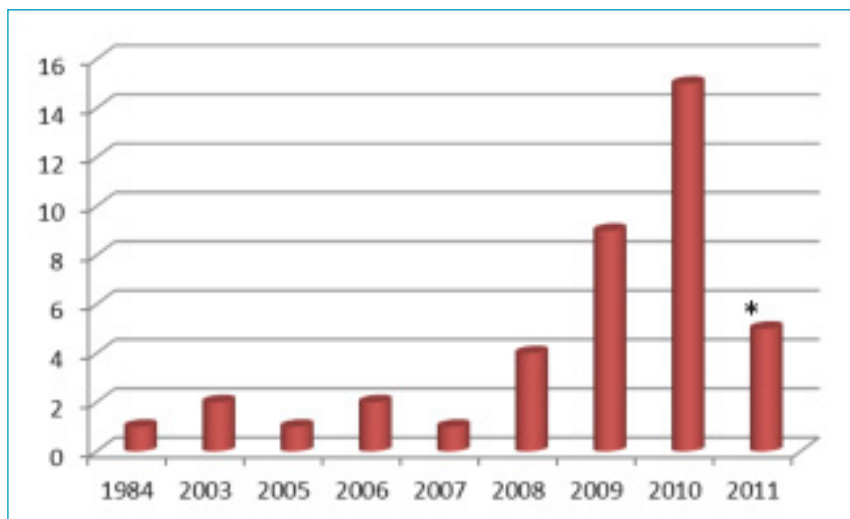
**[SOURCES: 1-2]**

## THE SOLAR VALUE CHAIN IN TENNESSEE

The solar value chain in Tennessee ranges from smaller start-ups to established manufacturing firms. Large manufacturing firms include:

- Sharp Manufacturing Company of America in Memphis
- Shoals Technology, LLC, in Portland
- AGC Solar in Kingsport
- Hemlock Semiconductor in Clarksville (under construction)
- Wacker-Chemie in Bradley County (under construction)

From 2008–2011, the number of companies incorporating solar into their product line grew to 33 (Figure 3). Of those, nine were new businesses dedicated to solar. The rapid growth of companies selling solar services or products parallels the national PV installation trend shown in Figure 1.



**FIGURE 3. NUMBER OF FIRMS (N=38) BEGINNING TO SELL SOLAR SERVICES/PRODUCTS IN TENNESSEE. NINE OF THESE FIRMS WERE NEW BUSINESSES. (SOURCE: TNSVC SURVEY). \*DATA THROUGH JUNE 2011.**

This TNSVC needs assessment was designed, in part, to catalog all the solar businesses – large or small – in Tennessee.

Specifically, the objectives were to:

1. Identify firms currently in (or with potential to enter) the solar value chain.
2. Through electronic surveys and direct interviews, determine solar industry workforce needs within the solar value chain in Tennessee.
3. Interview and assess a subset of companies to identify challenges and opportunities and workforce development needs.

**THE U.S. SOLAR INDUSTRY GREW BY 69 PERCENT IN THE PAST YEAR, MAKING IT ONE OF THE FASTEST GROWING SECTORS IN THE U.S. ECONOMY, ACCORDING TO THE SOLAR ENERGY INDUSTRIES ASSOCIATION. [SOURCE]**

## SOLAR VALUE CHAIN SEGMENTS

For the purposes of this TNSVC needs assessment, the solar value chain is divided into six segments (Figure 4). This is a standard industry model that covers each facet of the industry, from R&D and raw materials to installation and service. Although the focus of this study was on manufacturers, distributors, and installers, the needs of R&D and materials-related firms were also recognized and included.

TSI examined industry databases, relevant research reports, and solar-related publications to gain an understanding of the solar value chain and the firms within it. TSI looked at completed studies that assessed the solar value chain and that forecast growth within the solar industry. This is a horizontal view of the solar value chain. Firms related to solar, but not clearly fitting into one of the categories above, are listed in a category labeled “Other.”

|                      |  |
|----------------------|--|
| <b>R&amp;D</b>       | Includes firms that participate in the research and development of technologies that contribute to the value chain.          |
| <b>MATERIALS</b>     | Includes firms that focus in raw materials that are used in the manufacturing of the components used in Solar Systems.       |
| <b>MANUFACTURING</b> | Includes firms that manufacture components used in Solar Systems.  |
| <b>INSTALLATIONS</b> | Includes firms that provide complete installation services to consumer and commercial customers.                             |
| <b>SERVICE</b>       | Includes firms that provide post-installation services. Also includes firms that focus on data management for solar systems. |

**FIGURE 4. SOLAR VALUE CHAIN FOR PHOTOVOLTAIC - INDUSTRY SEGMENTS.**

## TNSVC DATABASE

TSI created a database capturing all firms identified by various means (NAICS codes, websites, marketing literature, and direct contact) who have identified themselves as participants in the Tennessee Solar Value Chain (Table 7). From this database, TSI drew up a list of firms to be assessed further, focusing on for-profit firms currently participating in the TNSVC. In addition, businesses -- such as start-up solar companies -- that demonstrated a solid business case with plans to enter the TNSVC in one or more of the six value chain categories were assessed, as well.

To ensure that any current or potential firms not captured in the database were provided an opportunity to participate in the TNSVC needs assessment, an email was sent to the more than 10,000 contacts in the customer database of the University of Tennessee’s Center for Industrial Services (CIS). This email was also distributed through partnering organizations (e.g. TenneSEIA) in an attempt to identify all possible participants in one of the TNSVC six categories.

After review and updates of the database, the list of for-profit organizations has been narrowed to 174 firms. A total of 167 firms were ultimately deemed appropriate for inclusion in the “firms of interest” population in this phase of the assessment. Each of these 167 firms is either a for-profit company currently providing solar-related business activities in Tennessee (in one or more of the six categories), or is a for-profit company that has presented TSI with a good business case for being in or entering the solar value chain in Tennessee (e.g., solar-related start-up firms).

TSI collected information from these firms via online surveys and on-site visits. Survey data were collected from 70 online responses. Additionally, information was collected during more than 30 onsite visits to manufacturing firms to assess their needs first hand, and to identify areas for potential technical assistance.

**TABLE 6. TNSVC DATABASE - ORGANIZATIONS VERSUS CATEGORIES**

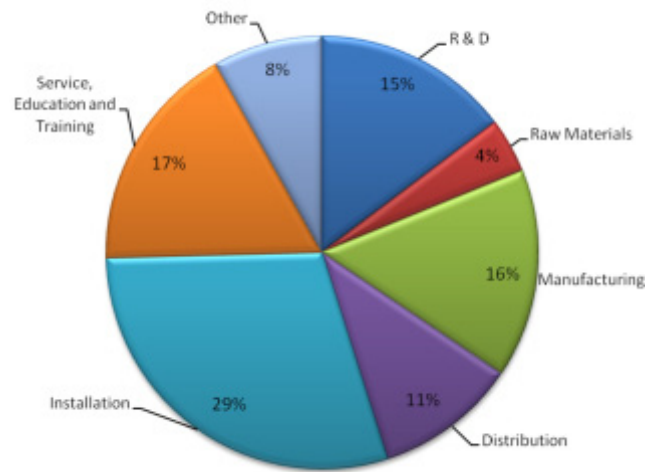
| SOLAR VALUE CHAIN                 | FOR PROFIT |             | FOR PROFIT |             |
|-----------------------------------|------------|-------------|------------|-------------|
| [Sector]                          | [Qty]      | [%FP]       | [Qty]      | [%NP]       |
| R&D                               | 4          | 2%          | 14         | 23%         |
| Materials, Manufacturing          | 22         | 13%         | -          | -           |
| Distribution                      | 24         | 14%         | -          | -           |
| Installation                      | 87         | 50%         | -          | -           |
| Service                           | 37         | 21%         | 15         | 23%         |
| Education                         | 0          | 0%          | 20         | 31%         |
| Solar Other<br>(hard to classify) | 0          | 0%          | 13         | 23%         |
| <b>Sub-Totals</b>                 | <b>174</b> | <b>100%</b> | <b>62</b>  | <b>100%</b> |

**AGC FLATGLASS IN KINGSPORT HAS 350 DEDICATED SOLAR JOBS. AGC KINGSPORT IS THE ONLY 100% DEDICATED SOLAR PATTERN GLASS MANUFACTURING PLANT IN NORTH AMERICA.**

# TSI SOLAR INDUSTRY NEEDS ASSESSMENT - ONLINE SURVEY RESULTS

## DISTRIBUTION OF BUSINESSES WITHIN THE TENNESSEE SOLAR VALUE CHAIN

TSI's analysis of online survey response provided an overview of the solar value chain in Tennessee. The distribution of responses from businesses in the solar value chain is presented in Figure 5. Installation is the largest sector in the value chain, with 29% of responding businesses. It is followed by services, education and training at seventeen percent. Of the firms that responded, 53% are in multiple sectors of the solar value chain, 39% have manufacturing operations in Tennessee (not necessarily solar sector operations).

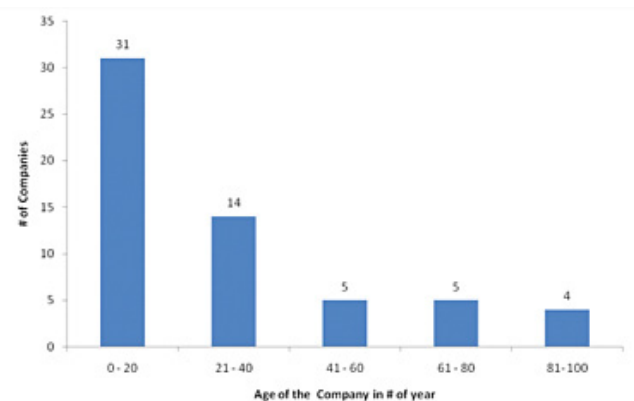


**FIGURE 5. DISTRIBUTION OF RESPONSES FROM  
BUSINESSES IN THE SOLAR VALUE CHAIN**

## COMPANY DEMOGRAPHICS

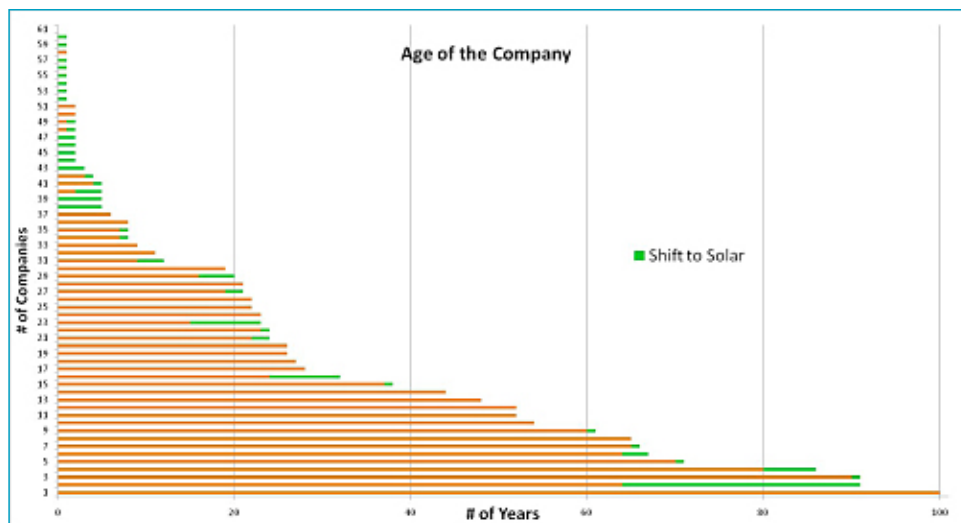
The average age of the companies in this survey response dataset (N=59) is 24.7 years, and the median age is 19 years. Thirty-seven respondents specified they are new entrants with respect to solar services and/or products, with 31 companies being less than 20 years old (Figure 6). This distribution indicates a majority of younger companies in the dataset (Figure 6). The average number of years a company has been in the solar-related value chain is 2.9 years; the median is one year.

The data indicate that older, well-established companies are also entering the solar market (Figure 7). Approximately 20% of the companies beginning to produce solar services and/or products are older than 50 years. Of these companies, 58% have fewer than 25 employees; 78% have fewer than 100 employees (Figure 8). This is of particular interest, because small businesses employ half of all American workers, and generally create 65% of new jobs.

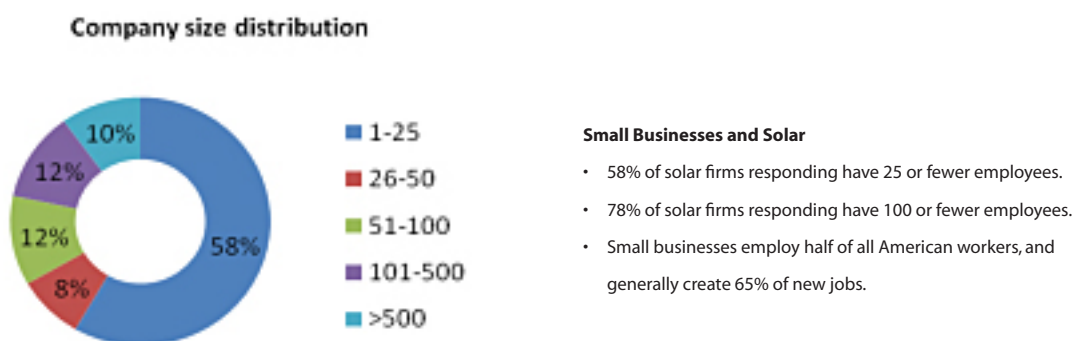


**FIGURE 6. AGE DISTRIBUTION OF COMPANIES (N=59)  
RESPONDING TO THE ASSESSMENT.**

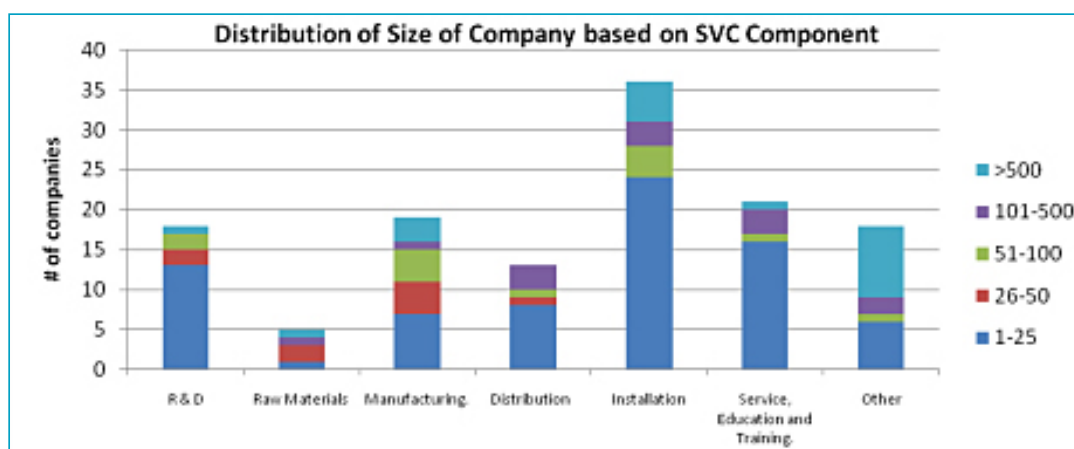
Ten percent of the companies have more than 500 employees. Company size is broken down by segment in the solar value chain (Figure 9). Note that of 59 respondents, 33 firms indicated participation in multiple segments of the solar value chain. The installation sector is the largest component of both the solar sector as a whole, and of the small-size company sub-sector of the value chain.



**FIGURE 7. DISTRIBUTION OF RESPONSES BASED ON AGE OF THE COMPANY (N=37). THE GREEN LINES INDICATE WHEN THE COMPANY ENTERED THE SOLAR MARKET.**



**FIGURE 8. COMPANY SIZE DISTRIBUTION BY NUMBER OF EMPLOYEES (N=60).**



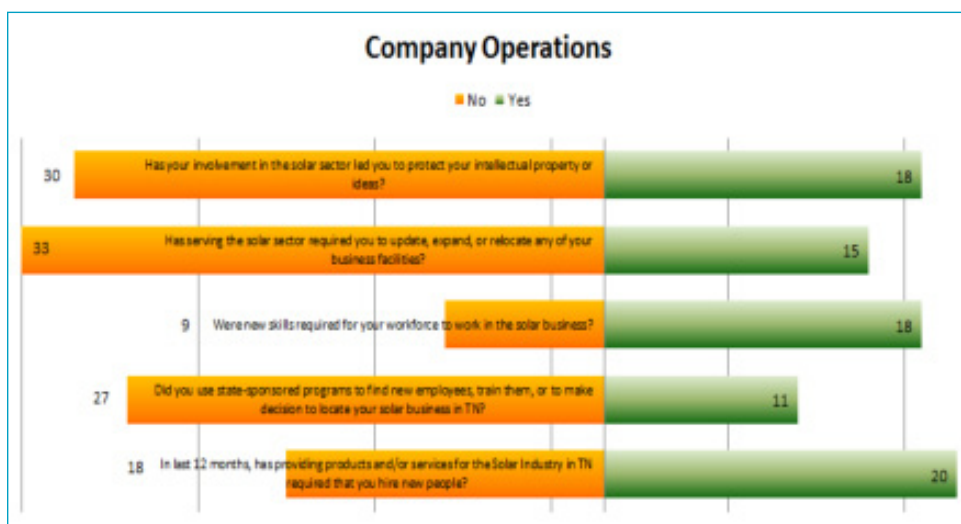
**FIGURE 9. COMPANY SIZE DISTRIBUTION VERSUS SEGMENT OF THE VALUE CHAIN (N=59). COMPANIES RESPONDING TO THE ASSESSMENT ARE IN MULTIPLE SEGMENTS OF THE SOLAR VALUE CHAIN.**

## COMPANY OPERATIONS: GROWTH

A series of broad questions tackled how companies are responding to growth in the solar value chain (Figure 10). The responses show that the solar energy industry in Tennessee is growing despite the recession, and that additional workforce training is required to meet the needs of this 21st century industry. They also show that entrepreneurs are fostering innovation in the solar supply chain.

For example:

- Fifteen of 48 respondents had to update, expand, or relocate operations as a result of growth due to their solar business.
- Twenty of 38 respondents reported hiring new workers in the last 12 months.
- Eighteen of 27 respondents state that employees need new skills to work in the solar industry.
- Eleven of 38 respondents used state-sponsored programs to find and train new employees, or to get assistance in locating their business.
- Eighteen respondents took steps to protect their intellectual property.

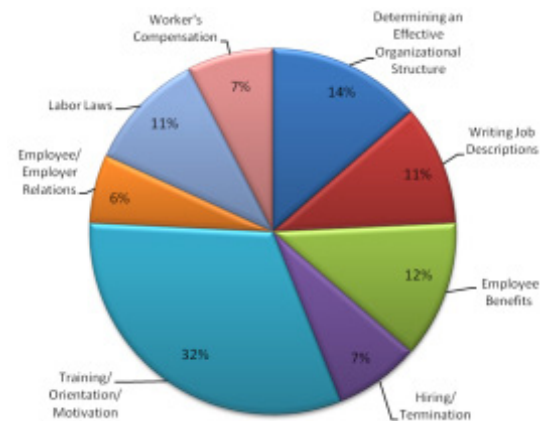


**FIGURE 10. GENERAL RESPONSES REGARDING GROWTH OF COMPANIES IN THE SOLAR VALUE CHAIN.**

A majority of the companies responding to this survey did not express concerns about locating suppliers, or difficulty in finding/hiring a sufficient number of workers in their solar sector. However, at least 70% of respondents reported that they were not aware of whether their suppliers were following an established quality and/or risk management system. At least 60% of respondents were not aware of whether their suppliers monitor customer satisfaction. TSI is following up on this question to better identify the reasons for this knowledge gap.

## COMPANY NEEDS: PERSONNEL AND HUMAN RESOURCE (HR)

This section of the assessment gathered information on management's needs in the areas of personnel and human resources. Figure 11 gives a detailed distribution of the types of needs based on specific industry sectors. Of respondents, 63% see employee training as a significant issue within the manufacturing sector. Across all sectors, one of the biggest personnel needs is “training/orientation/motivation,” followed by “determining an effective organizational structure” (Figure. 11).



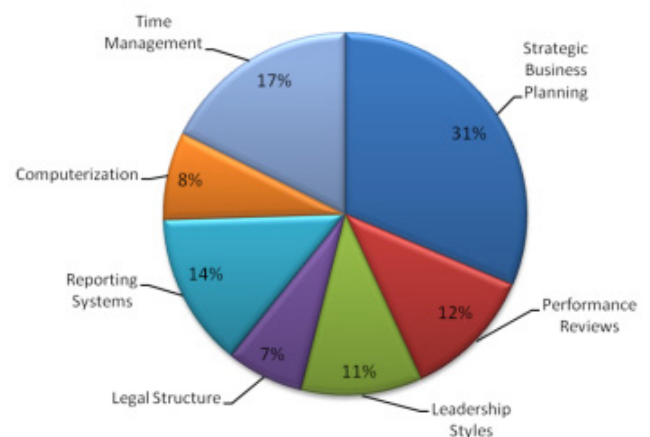
**FIGURE 11. DISTRIBUTION OF TYPES OF PERSONNEL NEEDS BASED ON SPECIFIC INDUSTRY SECTORS**

## COMPANY NEEDS: GENERAL MANAGEMENT ASSISTANCE

In the area of general management, 31% of the respondents said strategic business planning is a concern (Figure 12). Time management is another area where respondents might potentially seek assistance (17%).

Other findings of interest:

- Respondents have difficulty locating suppliers for laser cutting, high tech equipment, domestic suppliers with high quality standards, and electrical equipment providers.
- The most important criteria for supplier selection are product quality, financial stability, on-time delivery commitments, and supplier capabilities and capacities.
- Supplier quality management systems, supplier management of customer satisfaction, and risk measurement are critical supplier selection management criteria.
- Solar companies are seeking the establishment of standard quality management metrics and risk management policies for solar products.



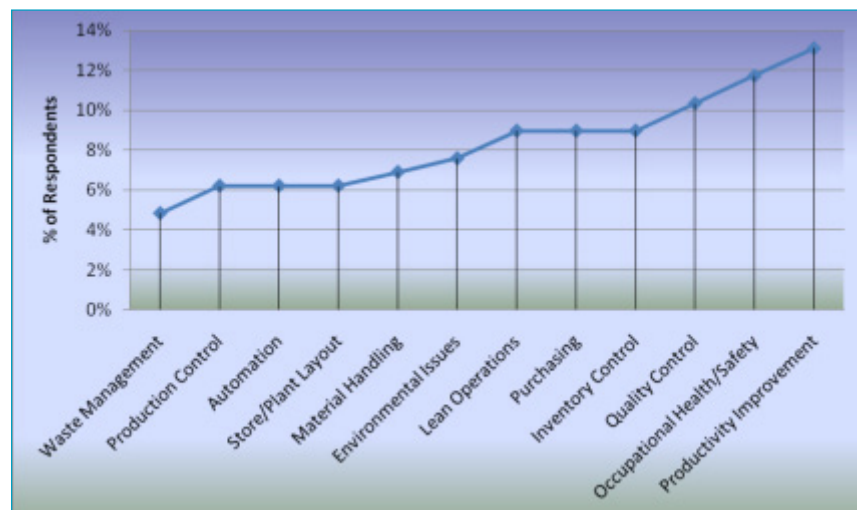
**FIGURE 12. DISTRIBUTION OF RESPONSES BASED ON GENERAL MANAGEMENT ASSISTANCE NEEDS (N=34).**



## COMPANY NEEDS: BUSINESS OPERATIONS

The needs of solar companies in the area of business operations are illustrated in Figure 13 below. Productivity improvements, occupational health and safety concerns, and quality control were the areas of need listed most frequently by the respondents. However, as the graph shows, a broad range of needs were listed.

FIGURE 13. DISTRIBUTION OF RESPONSES BASED ON BUSINESS OPERATION NEEDS



## SUPPLIER NEEDS

Analysis of open-ended responses regarding supplier needs revealed the following:

- Supplier quality management systems, supplier management of customer satisfaction, and risk measurement are important supplier selection management criteria (N=31).
- Solar companies need assistance in the establishment of standard quality management metrics and risk management policies (N=31).
- Although only 23% of respondents reported difficulty locating suppliers in general, the respondents also indicated that they have trouble locating suppliers for laser cutting, high tech equipment, domestic suppliers with high quality standards, and electrical equipment providers (N=30).
- The most important criteria for supplier selection are based on product quality, financial stability, on-time delivery commitments, and supplier capabilities and capacities (N=44).

**THE U.S. WAS A NET EXPORTER OF SOLAR PRODUCTS IN 2010, BY \$2 BILLION, ACCORDING TO THE SOLAR ENERGY INDUSTRIES ASSOCIATION. [SOURCE]**

The supply chain is an important part of the solar value chain, and based on the survey responses, it seems that additional work is needed to understand which parameters are most critical to optimizing and sustaining the solar supply chain in Tennessee. A more detailed assessment of the solar supply chain in Tennessee is recommended. Refer to the Conclusion and Appendix sections of this report for additional details.



# TSI SOLAR INDUSTRY NEEDS ASSESSMENT – SITE VISIT RESULTS

## MANUFACTURING SECTOR

One outcome of the online survey was to provide support for “boots on the ground” technical assistance to firms within – or with reasonable potential to enter – the solar value chain in Tennessee. In addition, direct contact with manufacturing and installation firms provided first-hand feedback on these companies’ needs. Although many of the needs identified thus far dovetail with the online survey responses, some complementary feedback was noted by our consultants from the University of Tennessee’s Center for Industrial Services (CIS). A sampling of the workforce development needs observed on-site by CIS consultants include:

- Leadership training in efficient manufacturing techniques
- Supply Chain Analysis and improvement events for manufacturing startups
- Manufacturing process improvement events
- Specific manufacturing-related training for:
  - Brazing
  - Equipment set-up
  - Equipment maintenance
  - Visual performance tracking
  - Problem solving
  - Safety
  - Supplier development
  - Inventory management
  - Project management
- Manufacturing process assistance in:
  - Equipment selection and pilot demonstration
  - Process optimization
  - Cost analysis

Site visits to companies across Tennessee show that the manufacturing sector is expanding, and existing companies are seeking to expand into the solar market. Some manufacturers need specific technical assistance to modify existing production lines or modify processes in order to enter the solar market. Examples of the benefits such technical assistance could provide include:

- **Company One.** “The projected benefit of the completed project is estimated at \$1,000,000+ for the first year of full production volume. The benefits will include reduction in materials costs, labor costs, scrap/rework avoidance, installation/warranty costs, and waste reduction of all types.”
- **Company Two.** “Technical assistance will allow us to modify our manufacturing process and add 5-7 employees.”

Findings from the site visits suggest that providing support to the manufacturing segment of the solar value chain might have considerable economic impact.

## CONCLUSIONS AND RECOMMENDATIONS

One fact is clear: Tennessee's solar energy industry continues to grow despite the recession. By understanding the needs of the state's solar value chain and assessing the most strategic options for support, it is possible for Tennessee to gain a competitive edge and emerge as a national and international leader in the \$240 billion global clean energy market.

The solar industry in the state of Tennessee, while relatively new, is a vibrant and growing component of the emerging clean energy economy. Tennessee is experiencing rapid growth in the solar industry, from the arrival of new multinational firms, to the rise of dozens of small businesses to established businesses adding solar components to their range of products and services.

With approximately 297,000 Tennesseans out of work, the solar energy industry represents a viable option to help put Tennesseans back to work and enable our workforce with 21st century skills.

Growth in the solar energy industry is not limited to Tennessee. Regionally, Georgia, Florida, North Carolina and Virginia have also been listed in the top 20 states for solar jobs. This suggests Tennessee is at a crossroads: Tennessee can either support opportunities for the solar energy supply chain, or concede solar industry growth to our neighbors. The TNSVC study represents the first step in assessing where our best options exist.

The purpose of this assessment was to determine what industries are in the solar value chain in Tennessee, and to formulate a high-level view of the health and needs of the industry. This qualitative assessment is a first step toward a better understanding of Tennessee's solar value chain and the economic development opportunities it presents.

There are 174 companies verified to date as being in Tennessee's solar value chain, ranging in age from one year to 90+ years old. The demographics portray a young but growing solar industry, with 33 new entrants since 2008, and 15 of those in 2010 alone. The average age of companies responding to the survey is 24.7 years, while the average number of years doing business in the solar market is only 2.9 years. This indicates that well-established companies see value in-- and are diversifying into-- solar markets. Of all the respondents, 58% are small businesses, with 25 employees or less.

A descriptive picture of the solar value chain in Tennessee demonstrates:

- Approximately 236 organizations (174 for-profit, and 62 non-profit) self-identify as being currently in the solar value chain.

- Tennessee hosts over 6,400 jobs in solar and solar-related industries, including solar photovoltaic installers, team assemblers, electricians and energy auditors, according to MTSU’s “Green Jobs Report” (2011).<sup>8</sup>
- These organizations spanned R&D (18), materials & manufacturing (22), distribution (24), installation (87), service (52), education (20), and other (13).

8 Murat Arik and David A. Penn. Green Jobs in Tennessee: Economic Impact of Selected Green Investments. Middle Tennessee State University, 2011.

Installation (50%), service organizations (21%), and manufacturing/materials (22%) accounted for approximately 93% of the for-profit firms.

Educational (20), R&D (14), service (15), and other organizations (13), accounted for the non-profit organizations claiming to be part of the solar value chain.

This is a young industry with many new players, and the firms in Tennessee’s solar value chain have many workforce, technical, and financial needs that must be met if they are to grow and sustain their operations. These needs span all segments of the value chain and all areas of solar businesses, including management, sales and marketing, workforce development, and operations.

There are economic benefits in providing technical assistance to all sectors of the solar value chain. Site visits suggests an especially significant economic impact would be realized if support were given to the manufacturing sector, in particular.

## FUTURE WORK

This workforce development needs assessment is only the first step in providing the cohesive, strategic approach needed to sustain and grow the solar value chain in Tennessee. State and federal energy policy and incentives were not a focus of this assessment. They are, however, very important to sustaining TNSVC firms within Tennessee, and should be addressed in subsequent studies.

The next phase of TSI’s work will focus on understanding current capacity and demand for solar products, and identifying bottlenecks and issues which must be addressed to facilitate growth in Tennessee’s solar value chain. This information will drive further strategic planning and organizational initiatives with an eye toward long-term sustainability.

# APPENDICES

TNSVC LIST OF FOR-PROFIT FIRMS

TNSVC LIST OF NON-PROFIT FIRMS

ASSESSMENT QUESTIONNAIRE

## APPENDIX A-1. TNSVC LIST OF FOR-PROFIT FIRMS

| COMPANY NAME                                | COUNTY     | NAICS  | CITY              | COMPANY TYPE |
|---|------------|--------|-------------------|--------------|
| Alpine Power Systems                        | Rutherford | 42361  | La Vergne         | Distributor  |
| Big Frog Mountain Corporation               | Hamilton   | 42361  | Chattanooga       | Distributor  |
| Day & Night Solar                           | Shelby     | 42372  | Memphis           | Distributor  |
| Gexpro                                      | Davidson   | 4236   | Nashville         | Distributor  |
| Grainger Industrial Supply - Nashville #512 | Davidson   | 42383  | Nashville         | Distributor  |
| Harris Electric Supply/BSE - Nashville      | Davidson   | 42361  | Nashville         | Distributor  |
| Hawker Powersource                          | Hamilton   | 42361  | Ooltewah          | Distributor  |
| Kemery Company                              | Jefferson  | 42369  | Strawberry Plains | Distributor  |
| Master Battery                              | Knox       | 42361  | Knoxville         | Distributor  |
| Mid-South Alternate Energy                  | Shelby     | 42369  | Memphis           | Distributor  |
| National Solar Supply                       | Monroe     | 42372  | Tellico Plains    | Distributor  |
| Paradoxe Corporation                        | Madison    | 42399  | Jackson           | Distributor  |
| Pro Charging Systems, LLC                   | Rutherford | 42361  | LaVergne          | Distributor  |
| PVD Solutions, LLC                          | Davidson   | 42369  | Madison           | Distributor  |
| Ready Made Resources                        | Monroe     | 621999 | Tellico Plains    | Distributor  |
| Schneider Electric, USA Inc.                | Davidson   | 42361  | Nashville         | Distributor  |
| SELECT SOLAR & GENERATOR                    | Sumner     | 42369  | Hendersonville    | Distributor  |
| Simple Energy Works, LLC                    | Cumberland | 453998 | Crossville        | Distributor  |
| Solar & Renewable Power Systems, LLC        | Madison    | 42372  | Jackson           | Distributor  |
| Stokes Electric Company                     | Knox       | 4236   | Knoxville         | Distributor  |
| Sunshine Works                              | Franklin   | 44419  | Winchester        | Distributor  |
| Sustainable Energy Mgt. Solutions           | Madison    | 23713  | Jackson           | Distributor  |
| Thermal Dynamics, LLC                       | Williamson | 23822  | Brentwood         | Distributor  |
| Vigilant Power Solutions                    | Dyer       | 4236   | Dyersburg         | Distributor  |
| Subtotal                                    |            |        |                   | 24           |
| A-1 Electrical Contractors, Inc.            | Shelby     | 23713  | Memphis           | Installation |
| A-C Electric Company, Inc.                  | Shelby     | 23821  | Memphis           | Installation |
| Action Services Group                       | Knox       | 23821  | Knoxville         | Installation |
| Adman Electric                              | Hamilton   | 23821  | Chattanooga       | Installation |
| Advent Electric                             | Knox       | 23821  | Knoxville         | Installation |
| Alicity Clean Energy, LLC                   | Hamilton   | 23713  | Chattanooga       | Installation |
| Alta Constructors, LLC                      | Davidson   | 23622  | Nashville         | Installation |
| Alter Eco Systems LLC                       | Dickson    | 23822  | Vanleer           | Installation |
| Alternate Energy Group - Knoxville          | Knox       | 333414 | Knoxville         | Installation |
| America Power Online                        | Shelby     | 23713  | Memphis           | Installation |
| AmmiTech Solutions, Inc.                    | Davidson   | 23713  | Nashville         | Installation |
| Amteck, LLC                                 | Dyer       | 23821  | Dyersburg         | Installation |
| Appalachian Renewable Resources             | Knox       | 23821  | Knoxville         | Installation |
| Beyond Sunny Money Inc.                     | Loudon     | 23713  | Loudon            | Installation |
| Bountiful Energy                            | Hickman    | 23713  | Bon Aqua          | Installation |
| Bricks Incorporated                         | Shelby     | 23814  | Memphis           | Installation |

## APPENDIX A-1. TNSVC LIST OF FOR-PROFIT FIRMS (CONTINUED)

| COMPANY NAME                                  | COUNTY     | NAICS  | CITY         | COMPANY TYPE |
|---|------------|--------|--------------|--------------|
| Broadway Electric Service Corporation (BESCO) | Knox       | 23821  | Knoxville    | Installation |
| C.O.Christian & Sons Co., Inc.                | Davidson   | 23821  | Nashville    | Installation |
| Cara-Sol Energy, LLC                          | Knox       | 333414 | Knoxville    | Installation |
| CGI Electric                                  | Williamson | 23821  | Brentwood    | Installation |
| Choice Mechanical                             | Davidson   | 23821  | Nashville    | Installation |
| DayStar Energy                                | Shelby     | 23713  | Cordova      | Installation |
| Dixie Roofing                                 | Campbell   | 23816  | LaFollette   | Installation |
| Earthlog Equity Group                         | Jefferson  | 236115 | Talbott      | Installation |
| Efficient Energy of Tennessee                 | Knox       | 23822  | Knoxville    | Installation |
| Elec-Tech Electrical Services, Inc.           | Davidson   | 23821  | Nashville    | Installation |
| Energy Design Unlimited                       | Davidson   | 81131  | Old Hickory  | Installation |
| Enterprise Electric                           | Davidson   | 23821  | Nashville    | Installation |
| ESG Construction, LLC                         | Knox       | 54133  | Knoxville    | Installation |
| FLS Energy                                    | Knox       | 23822  | Knoxville    | Installation |
| ForeverGreen Solar, LLC                       | Williamson | 23713  | Nashville    | Installation |
| Garth Hawkins Installations                   | Cannon     | 23713  | Woodbury     | Installation |
| Gold Power Solar                              | Maury      | 23713  | Columbia     | Installation |
| Grant-Neil Electric Inc.                      | Hamilton   | 23821  | Hixson       | Installation |
| Green Earth Solar ,LLC                        | Knox       | 238220 | Knoxville    | Installation |
| Greene Tech Renewable Energy                  | Greene     | 42372  | Midway       | Installation |
| Greener Tennessee Solar                       | Moore      | 23713  | Lynchburg    | Installation |
| Hawkeye Solar                                 | Knox       | 23713  | Knoxville    | Installation |
| Helios Renewable Energy                       | Shelby     | 23713  | Memphis      | Installation |
| Hoyt Hayes Construction, Inc.                 | Madison    | 23622  | Jackson      | Installation |
| HVAC, Inc                                     | Sullivan   | 23822  | Bristol      | Installation |
| Inman Solar                                   | Shelby     | 54199  | Germantown   | Installation |
| Integrated Solar                              | Davidson   | 23713  | Nashville    | Installation |
| J & S Construction                            | Putnam     | 23621  | Cookeville   | Installation |
| J Baker Electric, Inc                         | Blount     | 541519 | Louisville   | Installation |
| J.Ranck Electric                              | Davidson   | 23821  | Nashville    | Installation |
| JBC Solar                                     | McMinn     | 23713  | Athens       | Installation |
| Kee Electrical Contracting                    | Davidson   | 23821  | Nashville    | Installation |
| Krebs Ventures dba Construction Art           | Greene     |        | Afton        | Installation |
| Lakeland Electric                             | Putnam     | 23821  | Cookeville   | Installation |
| LE Darling & Sons                             | Rutherford | 23622  | Murfreesboro | Installation |
| Lee Company                                   | Williamson | 23822  | Franklin     | Installation |
| Lewis Mechanical Contractors, Inc. (LMC)      | Shelby     | 23713  | Memphis      | Installation |
| LightWave Solar Electric LLC                  | Davidson   | 23821  | Nashville    | Installation |
| Lindsey Brothers Electrical Contractors, Inc  | Rutherford | 23821  | Murfreesboro | Installation |
| Longo Electric LLC                            | Blount     | 335999 | Maryville    | Installation |
| Lowrie Electric CO Inc                        | Shelby     | 23821  | Memphis      | Installation |



## APPENDIX A-1. TNSVC LIST OF FOR-PROFIT FIRMS (CONTINUED)

| COMPANY NAME                                | COUNTY     | NAICS  | CITY             | COMPANY TYPE  |
|---|------------|--------|------------------|---------------|
| Mainstream Green Solutions, LLC             | Henderson  | 23713  | Lexington        | Installation  |
| Massey Electric Company                     | Blount     | 23821  | Alcoa            | Installation  |
| Metro Services, Incorporated                | Hamilton   | 23822  | Chattanooga      | Installation  |
| MidSouth Sustainable Energy Solutions, Inc. | Shelby     | 23821  | Memphis          | Installation  |
| New System Electric                         | Davidson   | 23821  | Nashville        | Installation  |
| Pointe General Contractors, LLC             | Hamilton   | 23713  | Chattanooga      | Installation  |
| Precision Electrical Company                | Sullivan   | 23821  | Kingsport        | Installation  |
| RCS Construction LLC                        | Hamilton   | 236115 | Chattanooga      | Installation  |
| S&T Control Wiring                          | Fayette    | 23821  | Moscow           | Installation  |
| S&W Contracting Co.                         | Rutherford | 23821  | Murfreesboro     | Installation  |
| Scott Electric                              | Hawkins    | 23822  | Rogersville      | Installation  |
| Shelby Electric Co.                         | Shelby     | 23821  | Memphis          | Installation  |
| Signal Energy LLC                           | Hamilton   | 23822  | Chattanooga      | Installation  |
| Solar Energy Consultants                    | Cheatham   | 23713  | Kingston Springs | Installation  |
| Solar Plexus Power                          | Davidson   | 42369  | Nashville        | Installation  |
| Solar Sales & Service, LLC                  | Dickson    | 42372  | White Bluff      | Installation  |
| Solar Solutions of Middle Tennessee         | Rutherford | 23822  | Rockvale         | Installation  |
| SolarTEK Energy Nashville                   | Davidson   | 23713  | Nashville        | Installation  |
| Solarwise                                   | McMinn     | 54171  | Athens           | Installation  |
| Southeast Electric                          | Robertson  | 23821  | White House      | Installation  |
| Southern Solar & Electric, Inc.             | Tipton     | 23821  | Brighton         | Installation  |
| Stansell Electric Company, Inc.             | Davidson   | 23821  | Nashville        | Installation  |
| Stones River Electric                       | Davidson   | 23821  | Madison          | Installation  |
| Sundog Solar Energy LLC                     | Davidson   | 23713  | Nashville        | Installation  |
| Sunny Solar                                 |            | 23713  |                  | Installation  |
| Sustainable Future LLC                      | Knox       | 42372  | Knoxville        | Installation  |
| Taylor Brothers Construction                | Gibson     | 236115 | Milan            | Installation  |
| Total Quality Environmental                 | Putnam     | 334413 | Cookeville       | Installation  |
| Tri-State Armature & Electrical Works, Inc. | Shelby     | 42361  | Memphis          | Installation  |
| Zuercher Electrical                         | Cumberland | 23821  | Crossville       | Installation  |
| SubTotal                                    |            |        |                  | 87            |
| AGC Flat Glass North America                | Sullivan   | 327211 | Kingsport        | Manufacturing |
| AOSmith American Water Heater Company       | Cheatham   | 335228 | Ashland City     | Manufacturing |
| ATN Hoelzel LP                              | Hamilton   | 336111 | Chattanooga      | Manufacturing |
| Contour Industries Inc.                     | Hawkins    | 327215 | Surgoinsville    | Manufacturing |
| Diversified Power Intl, LLC                 | Sullivan   | 336322 | Piney Flats      | Manufacturing |
| Eaton Corporation                           | Bradley    | 335313 | Cleveland        | Manufacturing |
| Hemlock Semiconductor Group                 | Montgomery | 334419 | Clarksville      | Manufacturing |
| James Thomas Engineering                    | Knox       | 332313 | Knoxville        | Manufacturing |
| Outpost Solar, LLC                          | Giles      | 23713  | Pulaski          | Manufacturing |
| Richland, LLC                               | Giles      | 3312   | Pulaski          | Manufacturing |
| Sam Dong Inc.                               | Hawkins    | 335929 | Rogersville      | Manufacturing |

## APPENDIX A-1. TNSVC LIST OF FOR-PROFIT FIRMS (CONTINUED)

| COMPANY NAME                              | COUNTY     | NAICS  | CITY           | COMPANY TYPE  |
|---|------------|--------|----------------|---------------|
| Seaman Corp., Ind. Fabric Div.            | Sullivan   | 31332  | Bristol        | Manufacturing |
| Sharp Manufacturing Company of America    | Shelby     | 339999 | Memphis        | Manufacturing |
| Shoals Technologies                       | Sumner     | 561499 | Portland       | Manufacturing |
| *   | *          | 212322 | *              | Manufacturing |
| Simple Control, Inc.                      | Knox       | 335211 | Knoxville      | Manufacturing |
| Solar Pathfinder                          | Perry      | 44411  | Linden         | Manufacturing |
| SolarFan                                  | Knox       | 333414 | Knoxville      | Manufacturing |
| Soltility                                 | Blount     | 56199  | Louisville     | Manufacturing |
| Storm Copper Components                   | Meigs      | 332999 | Decatur        | Manufacturing |
| Total Energy Company/EMPS                 | Anderson   | 335311 | Knoxville      | Manufacturing |
| Wacker Chemical Corporation               | Bradley    | 325199 | Charleston     | Manufacturing |
| Subtotal                                  |            |        |                | 22            |
| EPRI Solutions                            | Knox       | 54138  | Knoxville      | R&D           |
| Merrifield Engineering                    | Rutherford | 541330 | Smyrna         | R&D           |
| Mossey Creek Solar, LLC                   | Jefferson  | 333414 | Jefferson City | R&D           |
| Orion Laboratories, LLC                   | Anderson   | 339999 | Oak Ridge      | R&D           |
| Subtotal                                  |            |        |                | 4             |
| AECOM - Nashville                         | Davidson   | 541330 | Nashville      | Service       |
| Agate Foundations & Piering, Inc.         | Jefferson  | 54133  | New Market     | Service       |
| Ameresco Federal Solutions                | Knox       | 54133  | Knoxville      | Service       |
| America 4 Solar                           | Knox       | 56179  | Knoxville      | Service       |
| Apollo Energy Storage Corporation         | Davidson   | 541618 | Nashville      | Service       |
| ArgusON - SPX Brand                       | Williamson | 333415 | Franklin       | Service       |
| Artech                                    | Hamilton   | 54131  | Chattanooga    | Service       |
| Baker, Donelson, Bearman & Caldwell       | Davidson   | 54111  | Nashville      | Service       |
| Balfour Beatty Energy Solutions           | Davidson   | 23622  | Nashville      | Service       |
| CH2M Hill, Inc.                           | Anderson   | 541330 | Oak Ridge      | Service       |
| Double A Development                      | Davidson   | 23721  | Nashville      | Service       |
| Ecoville ArchiTechs                       | Perry      | 54131  | Linden         | Service       |
| Energy Source Partners, LLC               | Davidson   | 54133  | Nashville      | Service       |
| Energy Systems Group (ESG) - Johnson City | Washington | 541330 | Johnson City   | Service       |
| Enernex Corp.                             | Knox       | 54133  | Knoxville      | Service       |
| Free Energy 4 Tomorrow                    | Blount     | 23713  | Alcoa          | Service       |
| Green Home Solutions                      | Knox       | 561499 | Knoxville      | Service       |
| Green River                               | Knox       | 54135  | Knoxville      | Service       |
| H&M Company, Inc. - Jackson               | Madison    | 23622  | Jackson        | Service       |
| Hodge Associates                          | Knox       | 54133  | Knoxville      | Service       |
| Inverter Service Center                   | Robertson  | 44121  | White House    | Service       |
| Lab Four                                  | Shelby     |        | Memphis        | Service       |
| Lawson Electric                           | Hamilton   | 23821  | Chattanooga    | Service       |
| LK Browning & Associates                  | Williamson | 561499 | Franklin       | Service       |

## APPENDIX A-1. TNSVC LIST OF FOR-PROFIT FIRMS (CONTINUED)

| COMPANY NAME                        | COUNTY     | NAICS  | CITY        | COMPANY TYPE |
|-------------------------------------|------------|--------|-------------|--------------|
| Martin Group Realty                 | Shelby     | 53121  | Memphis     | Service      |
| Mcbee/Bailey & Associates           | Knox       | 561499 | Knoxville   | Service      |
| Mt. Pelia Innovative Solutions, LLC | Gibson     | 541330 | Milan       | Service      |
| Natural Energy Group                | Knox       | 56199  | Powell      | Service      |
| Renewed Venue                       | Davidson   | 54162  | Nashville   | Service      |
| Restoration Services, Inc.          | Anderson   | 221119 | Oak Ridge   | Service      |
| Self Tucker Architects, Inc.        | Shelby     | 54131  | Memphis     | Service      |
| Shelton Group                       | Knox       | 54181  | Knoxville   | Service      |
| *                                   | *          | 541611 | *           | Service      |
| SSOE Group                          | Williamson | 54133  | Brentwood   | Service      |
| Sun One Energy                      | Hamilton   | 23713  | Chattanooga | Service      |
| Tennessee Solar Solutions LLC       | Hamilton   | 23821  | Soddy Daisy | Service      |
| TerraShares                         | Hamblen    | 541611 | Morristown  | Service      |
| Subtotal                            |            |        |             | 37           |
| <b>TOTAL</b>                        |            |        |             | <b>174</b>   |

(\*) Identification withheld by request.

## APPENDIX A-2. TNSVC LIST OF NON-PROFIT FIRMS

| COMPANY NAME   | COUNTY     | NAICS | CITY         | COMPANY TYPE |
|--|------------|-------|--------------|--------------|
| Austin Peay State University                           | Montgomery | 61131 | Clarksville  | Educational  |
| Chattanooga State Comm. College                        | Hamilton   | 61121 | Chattanooga  | Educational  |
| Cleveland State Community College                      | Bradley    | 61121 | Cleveland    | Educational  |
| Columbia State Community College                       | Maury      | 61121 | Columbia     | Educational  |
| Dyersburg State Community College                      | Dyer       | 61121 | Dyersburg    | Educational  |
| Fisk University  | Davidson   | 61131 | Nashville    | Educational  |
| Jackson State Community College                        | Madison    | 61121 | Jackson      | Educational  |
| Middle Tennessee State University                      | Rutherford | 61131 | Murfreesboro | Educational  |
| Motlow State Community College                         | Coffee     | 61121 | Lynchburg    | Educational  |
| Nashville State Community College                      | Davidson   | 61121 | Nashville    | Educational  |
| Northeast State Tech. Comm. College - Gray             | Washington | 61121 | Gray         | Educational  |
| Pellissippi State Community College                    | Knox       | 61121 | Knoxville    | Educational  |
| Roane State Community College - Harriman               | Roane      | 61121 | Harriman     | Educational  |
| Southwest Tennessee Community College                  | Shelby     | 61121 | Memphis      | Educational  |
| Tennessee Board of Regents                             | Davidson   | 92311 | Nashville    | Educational  |
| Tennessee Technological University                     | Putnam     | 61131 | Cookeville   | Educational  |
| Tennessee Technology Center @ Pulaski                  | Giles      | 61121 | Pulaski      | Educational  |
| University of Memphis - Main                           | Shelby     | 61131 | Memphis      | Educational  |
| Volunteer State Community College                      | Sumner     | 61121 | Gallatin     | Educational  |
| Walters State Community College                        | Hamblen    | 61121 | Morristown   | Educational  |
| Subtotal   |            |       |              | 20           |
| Center for Holistic Ecology                            | Lewis      | 81399 | Hohenwald,   | Other        |
| Sequatchie Valley Institute                            | Marion     | 81399 | Whitwell     | Other        |
| Southern Alliance for Clean Energy - Knoxville         | Knox       | 81399 | Knoxville    | Other        |
| Sweet Water Sustainability Institute                   | Monroe     | 81399 | Sweetwater   | Other        |
| Technical Society of Knoxville                         | Knox       | 81392 | Knoxville    | Other        |
| TenneSEIA  | Knox       | 81399 | Knoxville    | Other        |
| Tennessee Solar Energy Association                     | Knox       | 81399 | Knoxville    | Other        |
| Tennessee Technology Development Corporation           | Davidson   | 54169 | Nashville    | Other        |
| The Climate Project United States                      | Davidson   | 81399 | Nashville    | Other        |
| The Farm   | Lawrence   | 81399 | Summertown   | Other        |
| TN Renewable Energy & Economic Development Council     | Knox       | 81399 | Knoxville    | Other        |
| US Green Building Council - Nashville                  | Davidson   | 81391 | Nashville    | Other        |
| University of Tennessee Center for Industrial Services | Davidson   | 61131 | Nashville    | Other        |
| Subtotal   |            |       |              | 13           |
| East Tennessee State University                        | Washington | 61131 | Johnson City | R & D        |
| King College   | Sullivan   | 61131 | Bristol      | R & D        |
| Oak Ridge National Laboratory                          | Anderson   | 54171 | Oak Ridge    | R & D        |

## APPENDIX A-2. TNSVC LIST OF NON-PROFIT FIRMS (CONTINUED)

| COMPANY NAME  | COUNTY   | NAICS | CITY           | COMPANY TYPE |
|---|----------|-------|----------------|--------------|
| Oak Ridge National Laboratory - Solar Technologies Program                            | Anderson | 54171 | Oak Ridge      | R & D        |
| Oak Ridge National Laboratory - Building Technologies Research and Integration Center | Anderson | 54171 | Oak Ridge      | R & D        |
| Tennessee Solar Institute   | Knox     | 61131 | Knoxville      | Other        |
| Tennessee State University  | Davidson | 61131 | Nashville      | R & D        |
| University of Tennessee - Center for Interdisciplinary Research & Graduate Education  | Knox     | 6113  | Knoxville      | R & D        |
| University of Tennessee, Knoxville - Office of Research                               | Knox     | 54171 | Knoxville      | R & D        |
| University of Tennessee, Knoxville - College of Architecture and Design               | Knox     | 6113  | Knoxville      | R & D        |
| University of Tennessee - Chattanooga   | Hamilton | 61131 | Chattanooga    | R & D        |
| University of Tennessee Institute for a Secure Sustainable Environment                | Knox     | 54171 | Knoxville      | R & D        |
| University of Tennessee Space Institute   | Coffee   | 61131 | Tulahoma       | R & D        |
| Vanderbilt University   | Davidson | 54171 | Nashville      | R & D        |
| Subtotal  |          |       |                | 14           |
| AIA Tennessee   | Davidson | 54131 | Nashville      | Service      |
| American Council of Engineering Companies - TN  | Davidson | 81391 | Nashville      | Service      |
| American Society of Civil Engineers - Nashville                                       | Davidson | 81392 | Nashville      | Service      |
| ASHRAE - Nashville  | Davidson | 81392 | Nashville      | Service      |
| Energy Services Coalition - Tennessee   | Davidson | 81391 | Nashville      | Service      |
| Green Spaces  | Hamilton | 81399 | Chattanooga    | Service      |
| Independent Electrical Contractors - Nashville  | Davidson | 81391 | Nashville      | Service      |
| Institute of Electrical & Electronic Engineers - TN                                   | Knox     | 81392 | Knoxville      | Service      |
| National Electrical Contractors Assoc. - ETN  | Hamilton | 81391 | Chattanooga    | Service      |
| Solar Knoxville   | Knox     | 81399 | Knoxville      | Service      |
| Tennessee Association of Roofing Contractors  | Sumner   | 81391 | Hendersonville | Service      |
| Tennessee Engineering Center  | Davidson | 81392 | Nashville      | Service      |
| Tennessee Mining Association  | Knox     | 81391 | Knoxville      | Service      |
| Tennessee Association of Plumbing HVAC Contractors                                    | Knox     | 81391 | Knoxville      | Service      |
| Tennessee Society of Professional Engineers   | Davidson | 81392 | Nashville      | Service      |
| Subtotal  |          |       |                | 15           |
| <b>TOTAL</b>  |          |       |                | <b>62</b>    |

## APPENDIX A-3 ASSESSMENT QUESTIONNAIRE

To help ensure consistency and reduce variation within the assessment process, a formal assessment questionnaire was developed.. Additionally, the Questionnaire and a description of its intended use was reviewed and approved by the University of Tennessee's Office of Research Institutional Review Board (IRB).

Design of the assessment questionnaire was based on information gathered from a combination of literature sources, in addition to input from internal technical and academic resources. Particularly useful were workforce assessments in California, the Appalachian Research Council study (2009) of Wind and Solar Manufacturing in Appalachia, and workforce development survey(s) of industry needs and training approaches. After careful consideration, it was decided that the TSI survey instrument design would include the following dimensions:

- I. Facility Information
- II. Workforce Needs
- III. Technical / Process Needs
- IV. Supplier / Vendor-Related Needs
- V. Financial Needs
- VI. Marketing Needs

### ASSESSMENT METHODOLOGY

Because an exploratory approach was used to identify firms participating in the TNSVC and their respective needs, promotion of the Needs Assessment was done in an open-ended manner. The intent was not to constrain the data gathering process to traditional survey methodology, but instead to use the questionnaire as a tool to help identify participants in TNSVC and their needs qualitatively as related to the six dimensions described above.

The Needs Assessment was promoted using a multi-mode approach. First, a targeted list of known TNSVC firms was prioritized and contacted electronically via email requesting completion of the assessment questionnaire online. Second, an email blast announcing the Workforce Development Needs Assessment and providing a link to the online questionnaire was emailed to a larger list of firms in the CIS customer database whose roles in the solar value chain were not known at the time. Also, TenneSEIA agreed to promote the Needs Assessment in its monthly newsletters. Finally, some firms were also made aware of the assessment directly by CIS personnel.

The promotional response rate is indeterminate, as the total number of individual contacts and firms receiving the announcement and solicitation for completing the assessment was open-ended and is unknown. Given the nature of this assessment, the determination and interpretation of an overall "survey" response rate in this case is not appropriate.

However, to help determine how representative the data gathered via the questionnaire were of the firms determined by TSI to be within the TNSVC, a “qualified response rate” of 42% was computed based on the percentage of for-profit firms identified as being targeted firms of interest in the TNSVC.

Promotion of the assessment and data collection took place over a two-month period during May–July 2011. Commercially available survey software (Survey Monkey™) was used to collect responses to the questionnaire. In addition to the electronic promotion, several potential respondents were contacted directly by CIS personnel either by phone or in person.

Initial analysis of assessment information collected via the questionnaire was completed by the University of Tennessee Knoxville (UTK) Industrial and Information Engineering (IE) Department.